Microwave L1b Assessment

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This report is based on a status report given to the AIRS Science Team in September 2002 - with updated information as appropriate.

Comments and updated information are provided as notes (like this).

MICROWAVE INSTRUMENTS

JPL

Instrument Status

Operations

- All three modules are fully operational

Instrument mode & state

- Normally in full scan mode
- Occasionally in warm-cal stare mode
  - S/C-safe causes MW-safe
- All three modules now use optimal space view position
  - HSB: SV4 (furthest from nadir, 11° below horizon)
  - AMSU: SV3 (next to closest to nadir, 10° below horizon)

Instrument stability

- Temperatures: very stable
  - RF-shelf temperatures vary by only fraction of a degree
- Radiometric gains: stable
  - No significant drifts seen
  - No lasting effect after cold soak (> 48 hours)

Channel	Gain
A-1	16.6
A-2	15.9
A-3	13.3
A-4	15.8
A-5	13.9
A-6	14.2
A-7	15.8
A-8	15.3
A-9	14.7
A-10	16.2
A-11	19.2
A-12	20.1
A-13	20.5
A-14	22.4
A-15	10.4
H-2	30.7
H-3	38.4
H-4	36.4
H-5	33.8

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HSB was put in survival mode in the beginning of February 2003, after it shuts its scanner down. This is thought to have been caused by either a synchronization glitch (of which there have been many - all minor glitches that the instrument has quickly recovered from) or a malfunction in its scan electronics. As of this writing, the expectation is that the instrument will be started up again in mid-March, and there is no reason to believe that it has been permanently damaged or suffered an unrecoverable fault.

There is no valid HSB L1b data during this period, and users should check for instrument status updates as to future availability of HSB data.

Note that the table on this page lists the gain for each AMSU and HSB channel.

MICROWAVE INSTRUMENTS

Calibration Status

Calibration algorithms

- As per ATBD
- Recently modified to compute calibration coefficients in Tb-space

Calibration parameters

- At-launch baseline tables have been updated; all now best known

Radiometric sensitivity

- Very good for all channels: all better than specs

Calibration accuracy

- Estimated at ≤ 1 K
- Aim is to improve it to ≤ 0.5 K

Summary

- Calibration is now very good; baseline performance
- Sidelobe correction not yet applied at L1b

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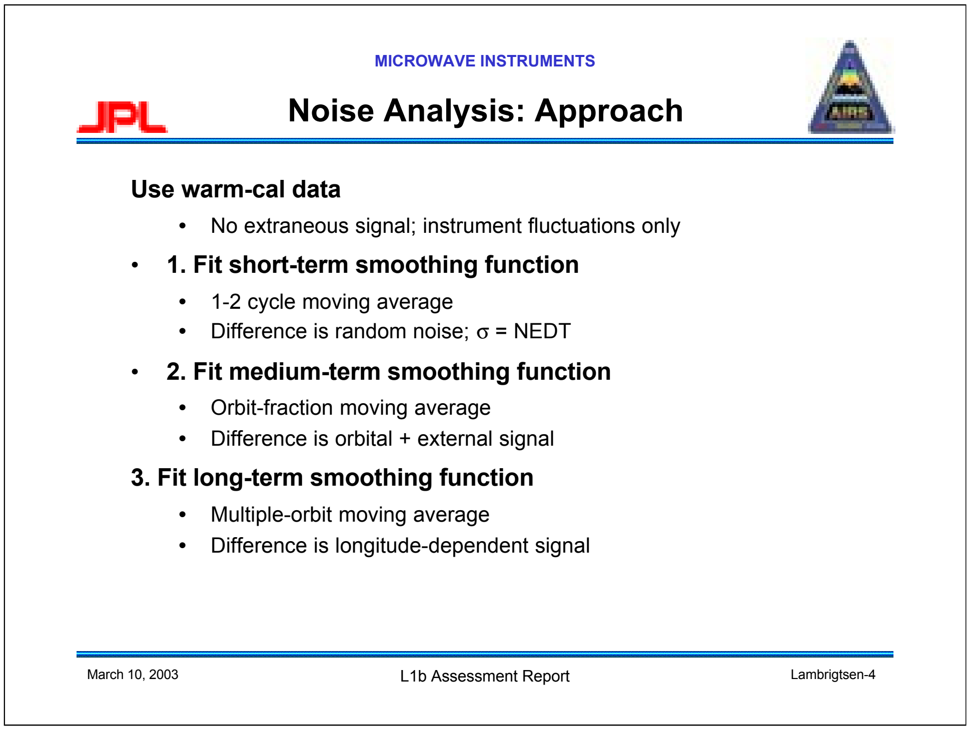
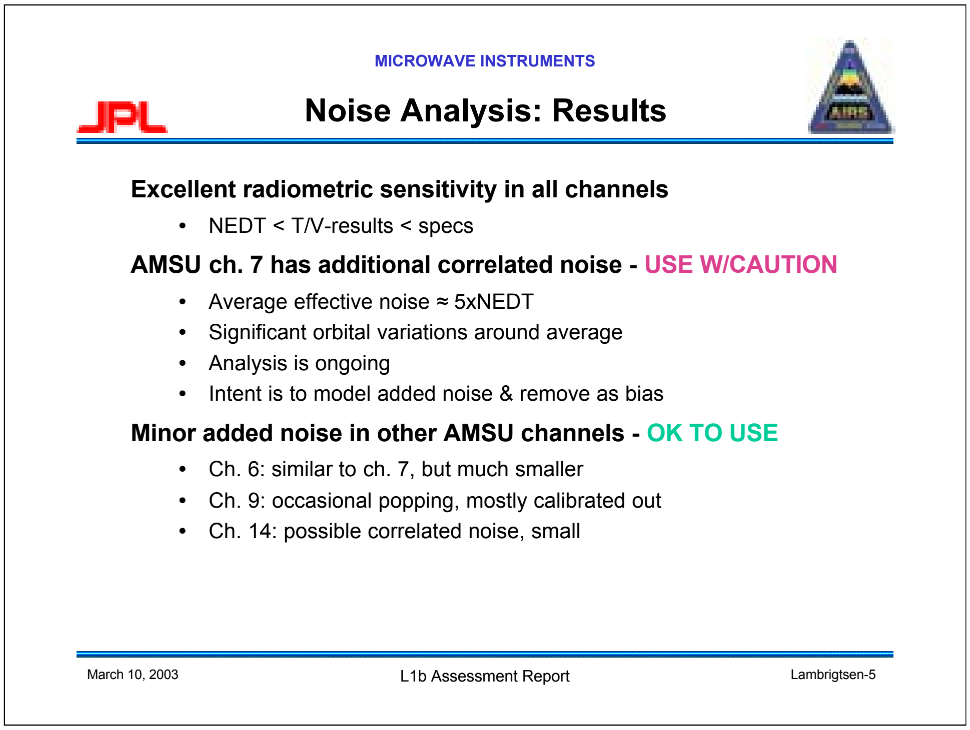
Although sidelobe corrections have not yet been applied, a new data slot has been created to accommodate them. The AMSU and HSB L1b data products now include both an ‘antenna_temp’ and a ‘brightness_temp’. The former is the uncorrected calibrated radiances (formerly called brightness temperatures), and the latter is the former with antenna sidelobe corrections applied. Until those corrections are actually implemented, users should use ‘antenna_temp’.



This page describes the approach that was used to generate the data used in the following plots and noise estimates. All such analysis has been based on data while the instruments have been in warm calibration mode (target stare mode). This eliminates large signals caused by Earth scene variability as well as calibration and sidelobe effects.

Illustrative examples are only given for AMSU, but equivalent analysis has been done for HSB.

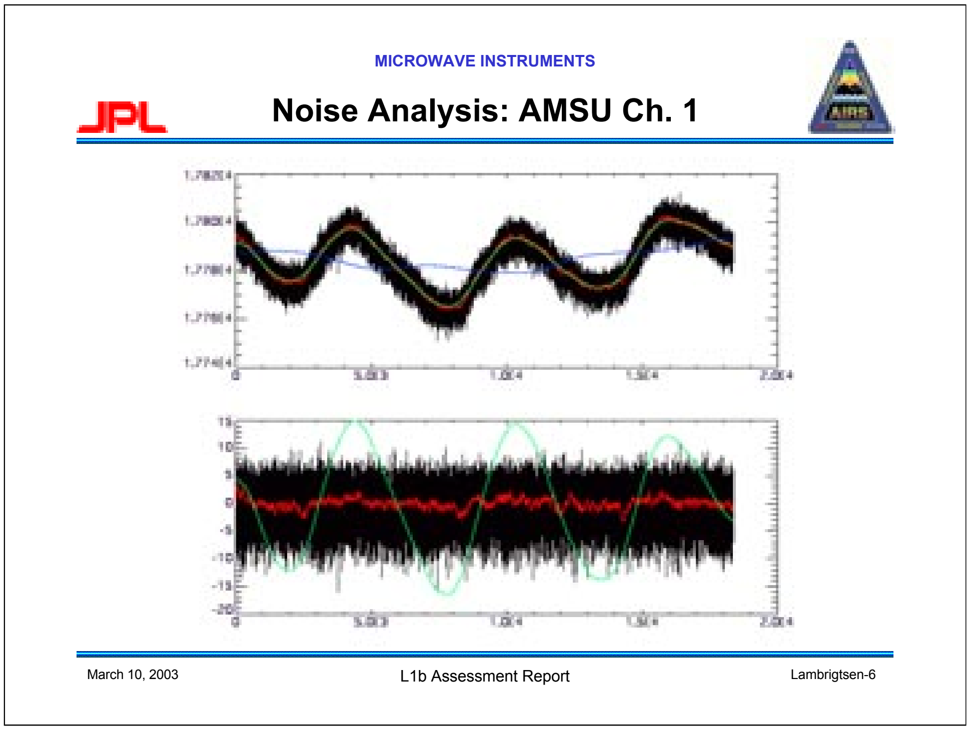


In summary:

1. All channels show excellent sensitivity (random noise level)
2. AMSU channel 7 exhibits substantial non-random noise
3. AMSU channel 9 exhibits occasional minor 'popping'

Recommendations to users:

1. Avoid AMSU channel 7 in applications that use single measurements (such as soundings). It is OK to use it in applications where some averaging is done (such as gridding/binning or regional averages)
2. All other channels are OK to use in most cases
3. Be aware that there are substantial scan biases



This shows the warm calibration counts for AMSU channel 1 over about 3+ orbits while in warm-cal stare mode.

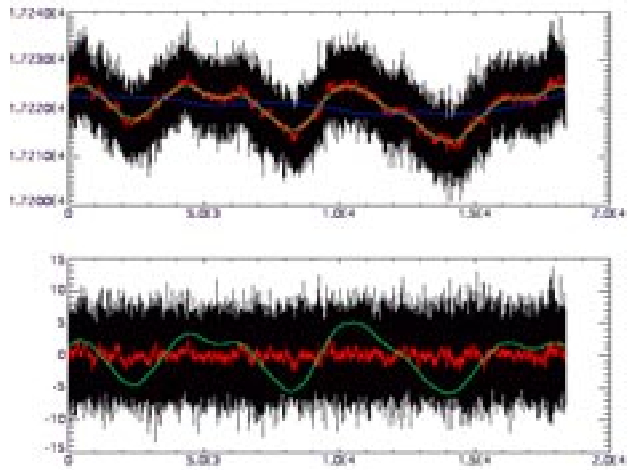
The top plot panel shows the observations (black) and various smoothing fits, from short-term (red) to medium-term (green) to long-term (blue).

The bottom panel shows the observations with medium-term variations removed. This is the basis for the NEDT estimates (which are computed as the standard deviation of this difference). This makes it possible to separate out rapid random fluctuations (measured by NEDT) from other, non-random, effects. (See channel 7 below for an example.)

Channel 1 does not appear to have any anomalies.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 2



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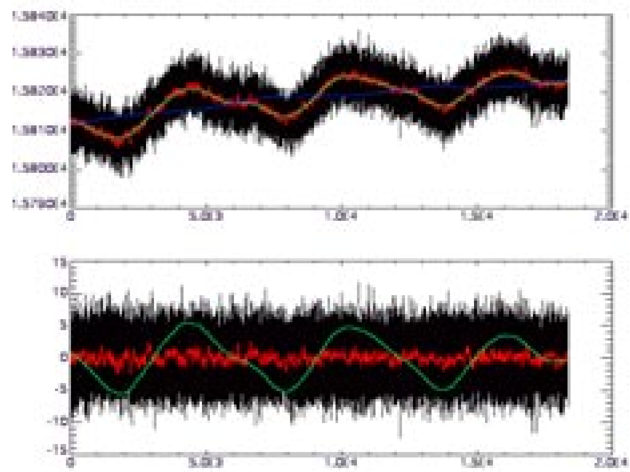
Channel 2 does not appear to have any anomalies.

However, the orbital signal is more complex than for channel 1.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 3



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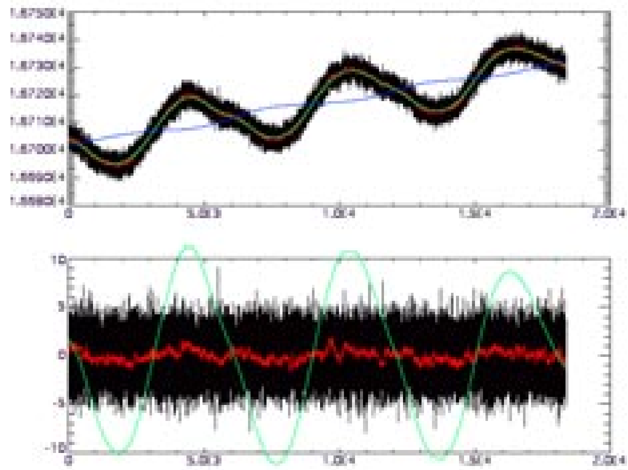
Channel 3 looks normal.

There is a clear secular trend, which implies longitudinal dependence.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 4



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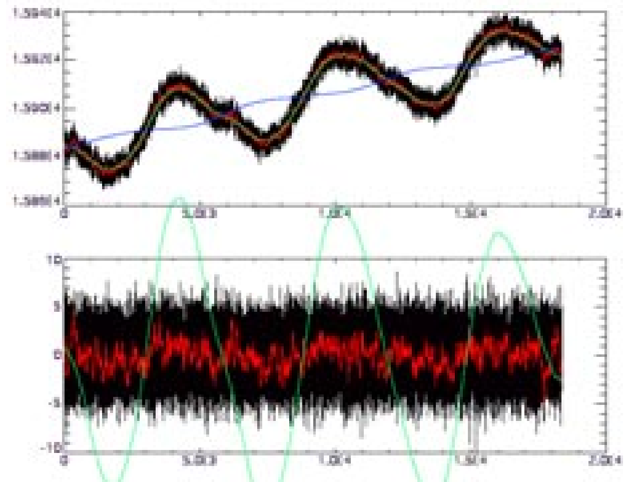
Channel 4 looks OK, with a clear secular trend.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 5



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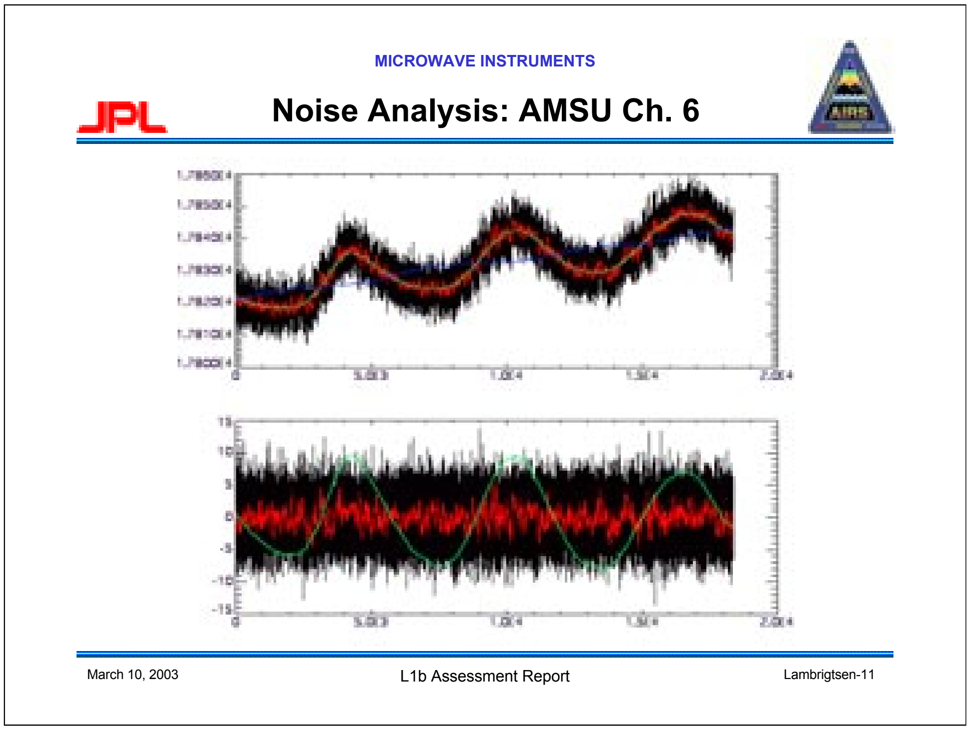
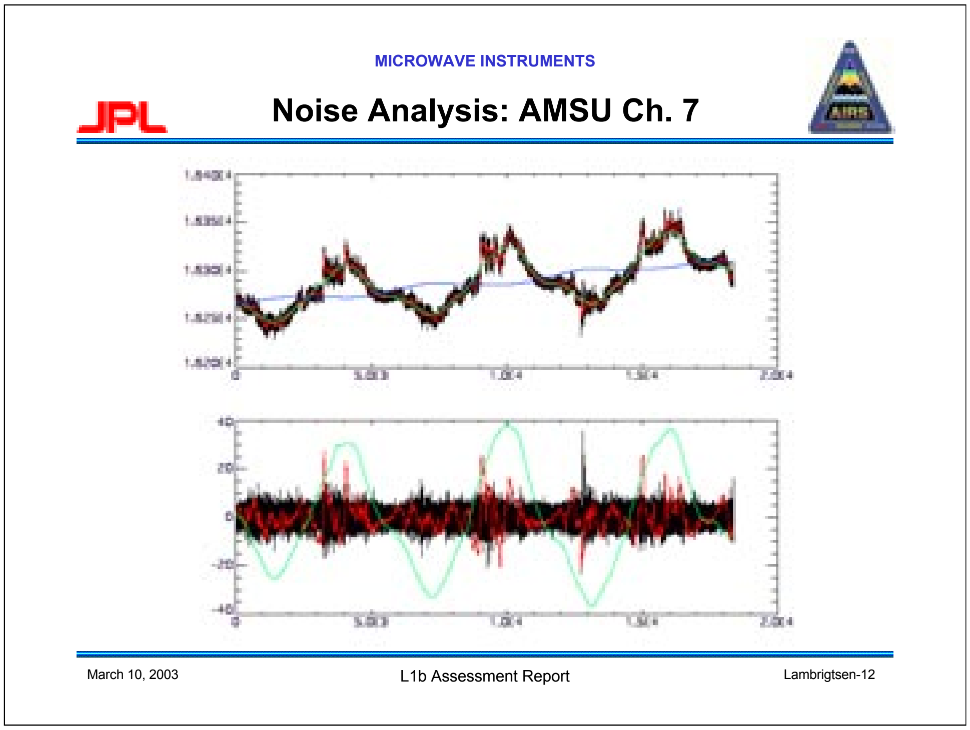
Channel 5 looks OK, with a clear secular trend.



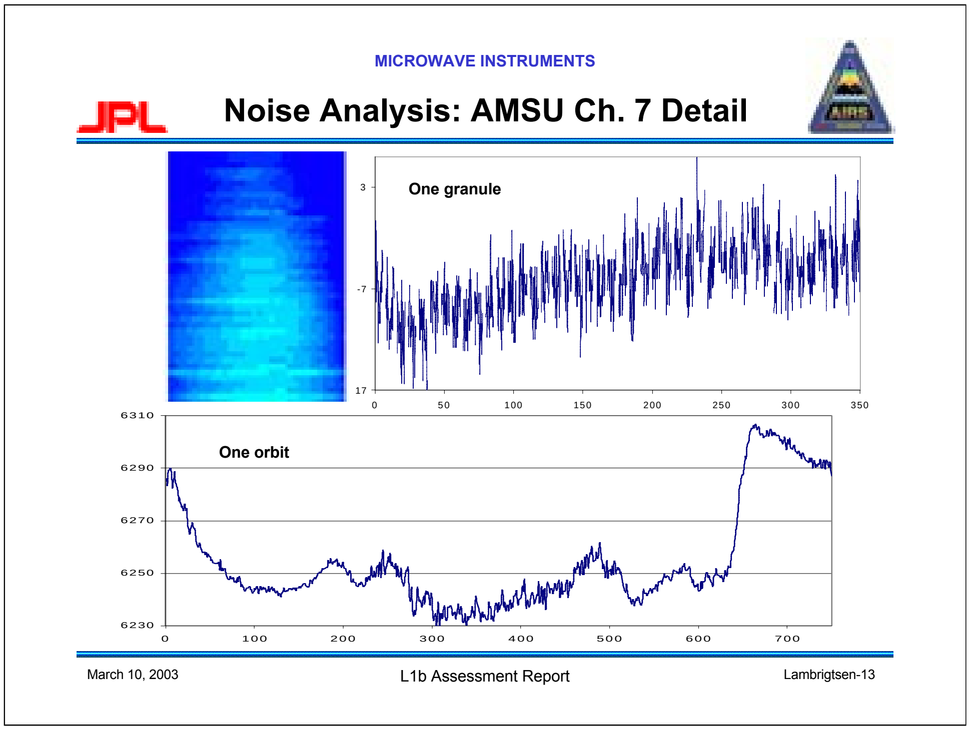
Channel 6 looks OK, also with a secular trend.



Channel 7 is clearly anomalous. Note that the vertical scale is quite different than for the other plots. There is a large anomalous signal superimposed on the normal orbital signal. The underlying random noise (as shown in the bottom panel) is normal, however, and the NEDT estimated from this is as expected.

The next page shows a close-up of the anomaly.

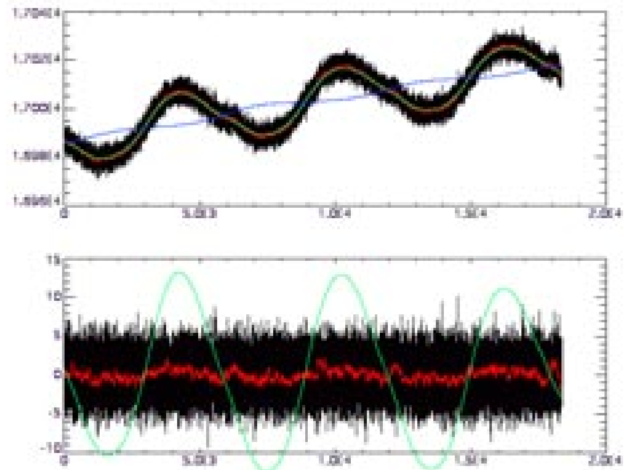
As of this writing, the cause has not been determined, nor has the effect been modeled. A working hypothesis is that the anomalous signal may be caused by interference - perhaps from the S/C transmitters.



The image at top-left shows the calibrated brightness temperatures for one granule (scan axis is from left to right, flight direction is from bottom to top). The streaks in the image indicate the duration of each anomaly event. The plot in the lower panel shows the long-term structure of the anomaly.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 8



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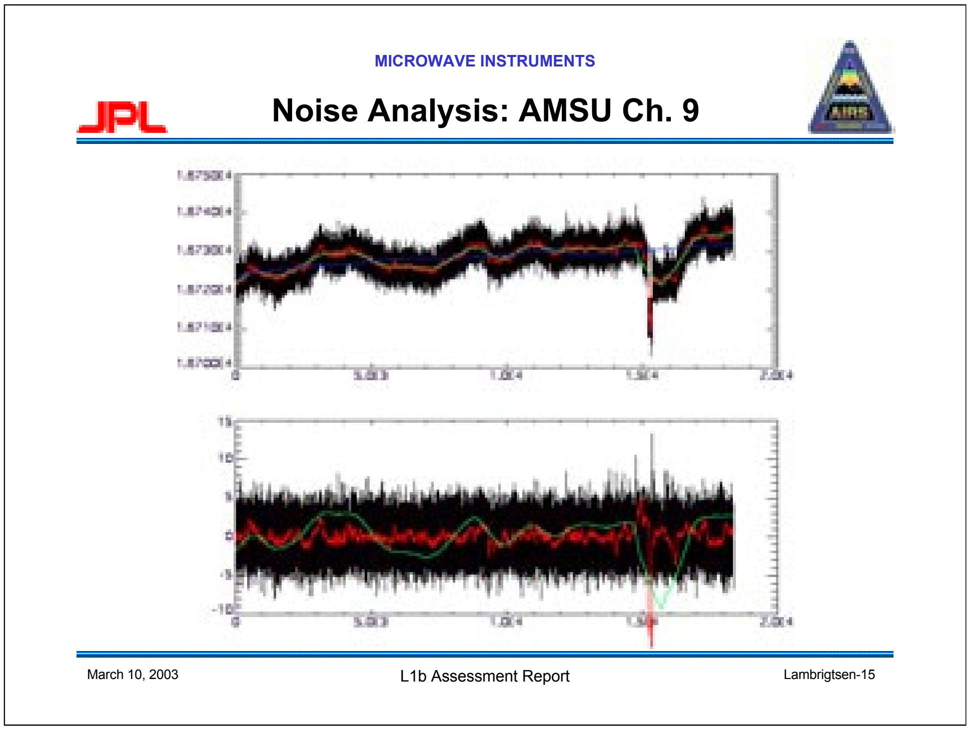
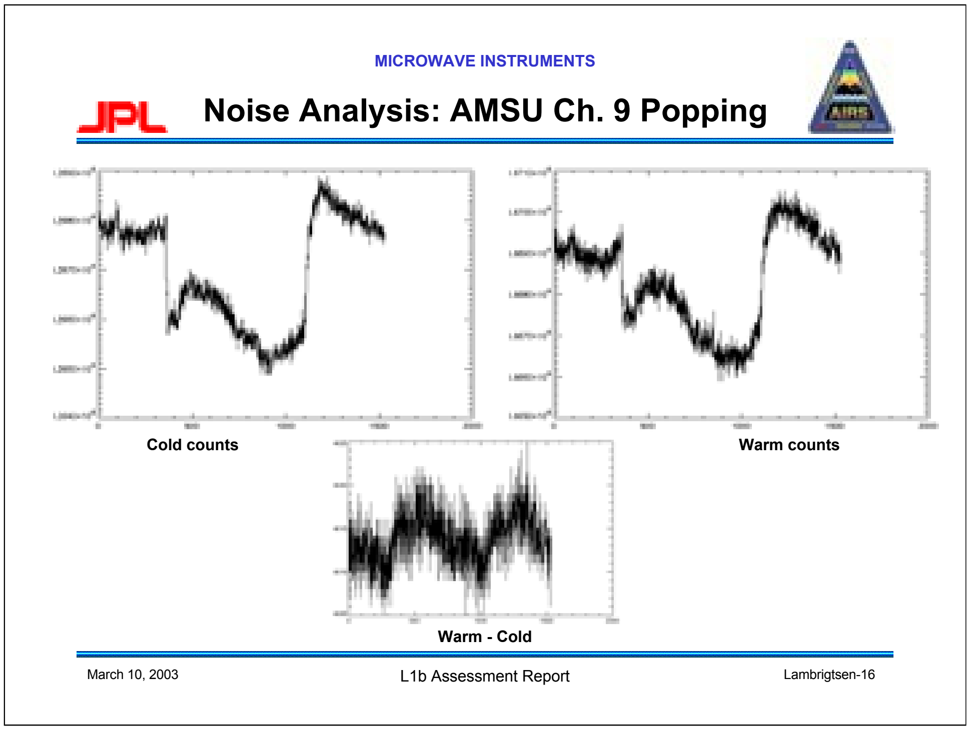
Channel 8 looks OK, with a noticeable trend.



Channel 9 exhibits some anomalies. The plots above illustrate a ‘popping’ event, where the calibration counts suddenly drop and then quickly recover. This typically happens at most once per orbit and usually less frequently.

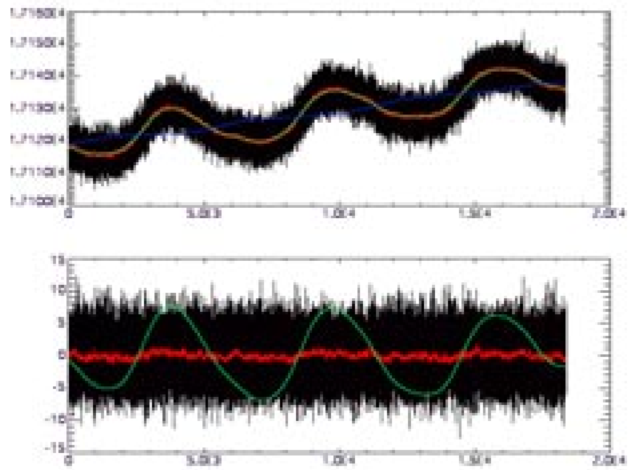
The next page shows a close-up of a popping event and illustrates that the effect on the calibration is negligible. Thus, it appears that it is the gain that suddenly and briefly changes, and that is mostly calibrated out.



Close-up of a ‘popping’ event. The bottom panel shows that the effect on calibration (and thus on the L1b data products) is negligible.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 10



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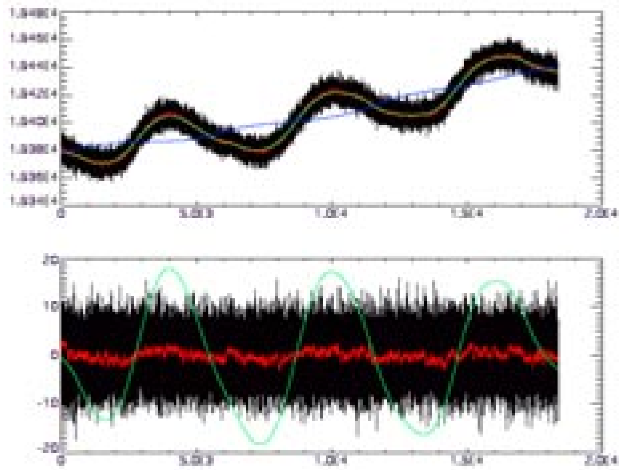
Channel 10 looks normal.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 11



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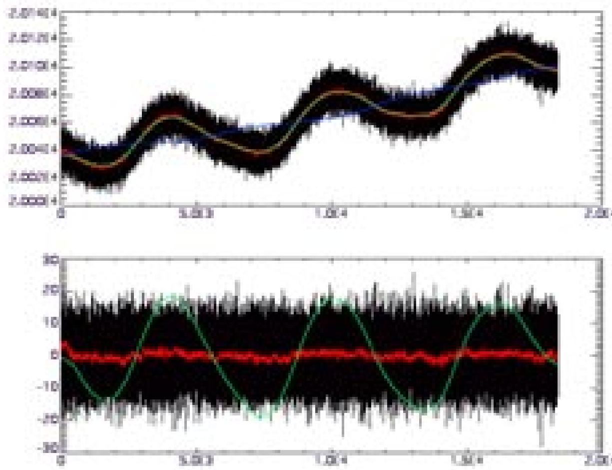
Channel 11 looks normal.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 12



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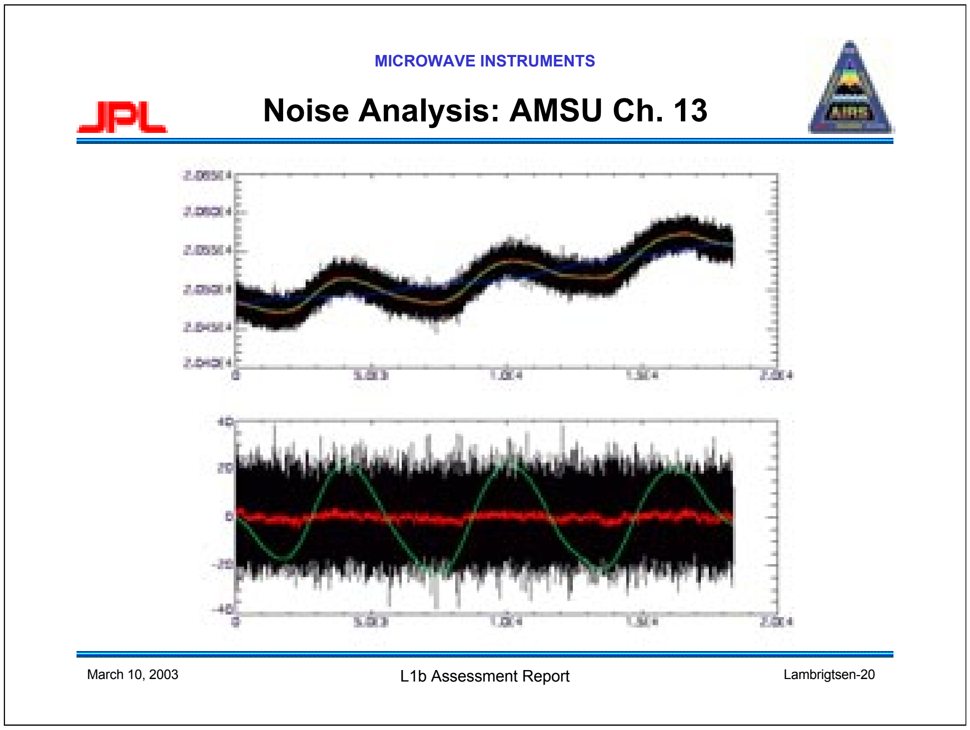
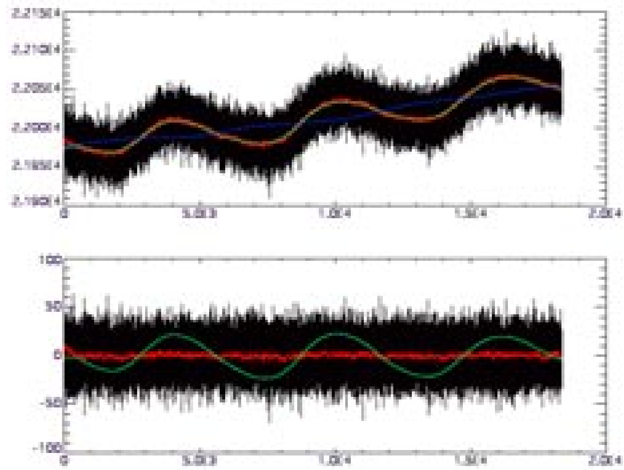
Channel 12 looks normal.



Channel 13 looks normal.

MICROWAVE INSTRUMENTS

Noise Analysis: AMSU Ch. 14



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Channel 14 looks normal.

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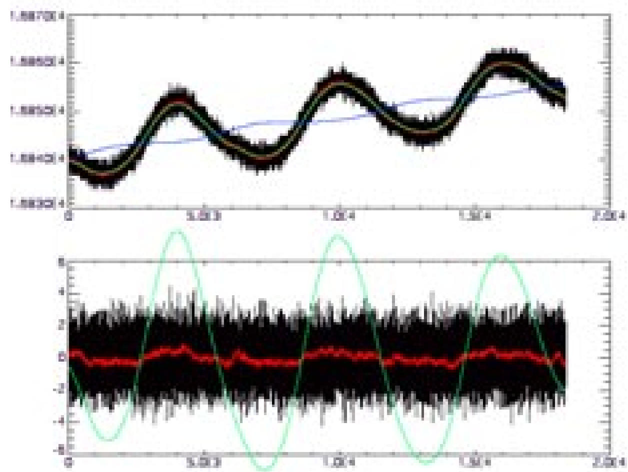
Noise Analysis: AMSU Ch. 15



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Channel 15 looks normal.

Pointing Analysis: Approach

Method 1: Nadir stare mode data

- High sampling density ⇒ Instantaneous accuracy ≤ 1/20 FOV
- Coast crossings: perpendicular ⇒ pitch error; oblique ⇒ roll error

Method 2: Full scan mode data

- Low sampling density ⇒ Instantaneous accuracy ≤ 1/2 FOV
- Swath-edge perpendicular crossings ⇒ yaw error
- Requires many samples for good stats

Both methods: Compare counts or Tb with "landfrac"

- "landfrac" is DEM convolved with antenna function
- Looks like observations, scaled to [0 - 1]
- Makes it possible to work in scan coordinate system
- Results are directly translatable to instrument coordinates
  - Ground speed ~ 0.54°/s in instrument coordinates
  - Angular coordinates: pitch, roll, yaw

Two methods have been devised to analyze instrument pointing. The following pages illustrate the first (and most precise) method, which uses nadir stare mode data. This is an extremely accurate method, which can be used to determine the pointing at nadir with just a few observations of coastal crossings.

MICROWAVE INSTRUMENTS

Pointing Analysis: Results

Only window channels can be analyzed using coastlines

- Good AMSU channels: 1, 2, 3, 15
- HSB: 2 only

AMSU results

- Pitch error: < 0.1xFOV (< 4 km at nadir)
- Roll error: not yet conclusive (est. < 0.2xFOV)
- Yaw error: not yet conclusive (est. < 0.3xFOV at swath edge)

HSB results

- Pitch error: < 0.1xFOV (< 1.5 km at nadir)
- Roll error: not yet conclusive (est. < 0.2xFOV)
- Yaw error: not yet conclusive (est. < 0.3xFOV at swath edge)

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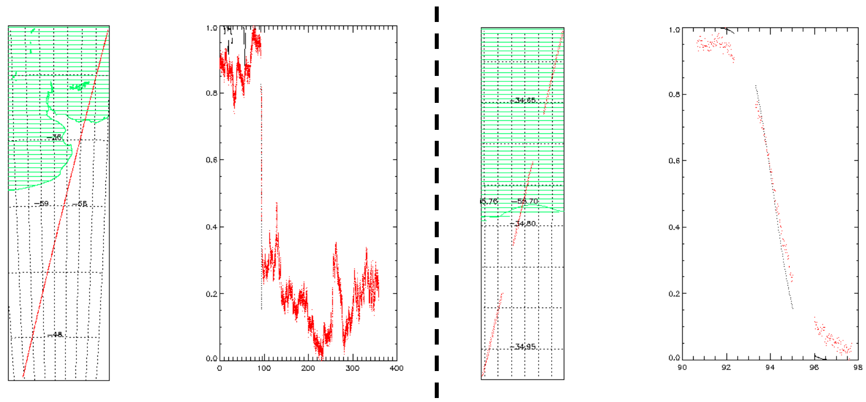
This is a summary of the preliminary pointing analysis. The analysis is on-going, and the final results will be released when completed.

MICROWAVE INSTRUMENTS

Pointing Analysis: Example 1

HSB channel 2: Perpendicular crossing (Uruguay)

Time error < 0.1 s ⇒ Pitch error < -0.05° ~ 5% of FOV (1.1°)



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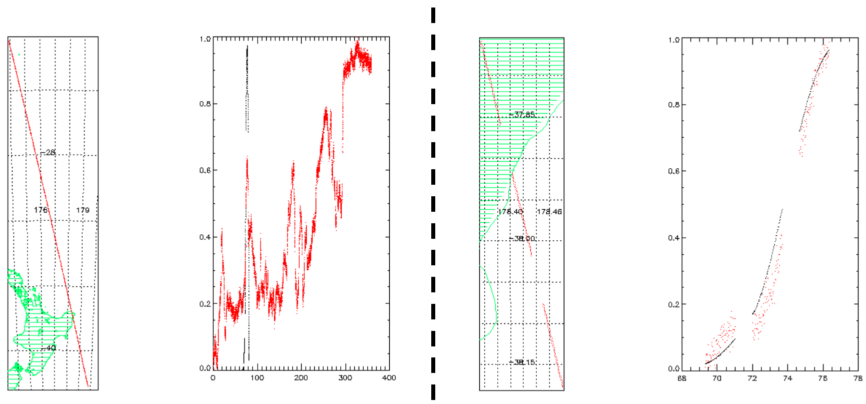
This illustrates the first method applied to two cases of HSB coast-line crossings while in nadir stare mode. Both are near-perpendicular crossings, which yield along-track pointing information.

MICROWAVE INSTRUMENTS

Pointing Analysis: Example 2

HSB channel 2: Oblique crossing (New Zealand)

Time error < 0.5 s; angle of attack ~ 45° ⇒ Roll error < 0.3° ~ 20% of FOV (1.4°)



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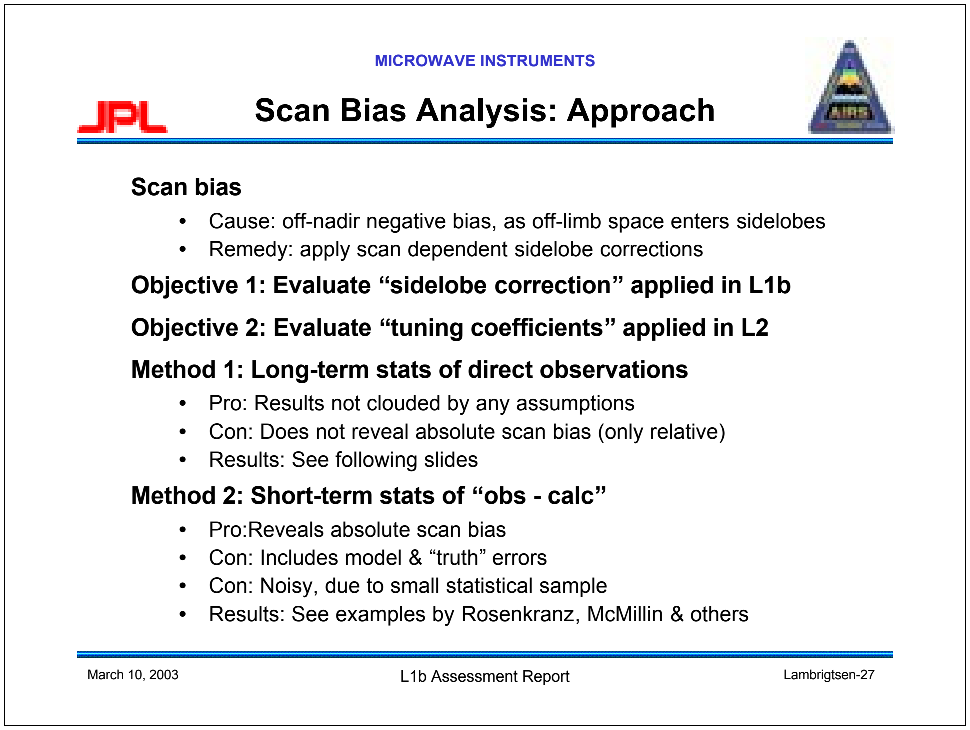
This illustrates two cases of oblique coast-line crossing (or close approach), which yields cross-track pointing information.



This is a brief discussion of the approach taken to the analysis of the observed scan bias and attempts to correct for it.

MICROWAVE INSTRUMENTS

Scan Bias Analysis: Results

AMSU-A1

- Scan bias is asymmetric
- Positive bias at *right* swath edge

AMSU-A2

- Scan bias is symmetric

HSB

- Scan bias is asymmetric
- Positive bias at *left* swath edge

Hypothesis: may be caused by asymmetric S/C environment

- Under investigation

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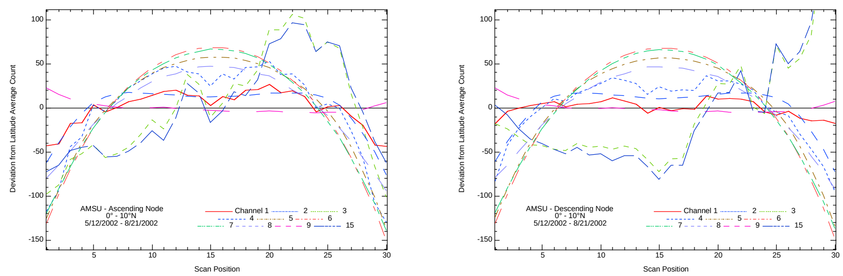
Recent results indicate that the asymmetric Aqua S/C environment seen by the microwave instruments (in particular AMSU-A1) may be the primary cause of the observed scan bias asymmetry. These results are not yet finalized but will be published as soon as they become available.

In the meantime, users are advised to approach this issue with caution and be aware that there is substantial and asymmetric scan bias. For now, the bias may be compensated for through so-called “tuning”, which is the approach the AIRS team has taken until now (applied at the L2 entry point). However, tuning assumes that both “truth” and forward models are good. Tuning thus carries with it possible unknown additional biases, and it is difficult to separate those from the instrument biases.

MICROWAVE INSTRUMENTS

Scan Bias Stats: AMSU



Near the equator

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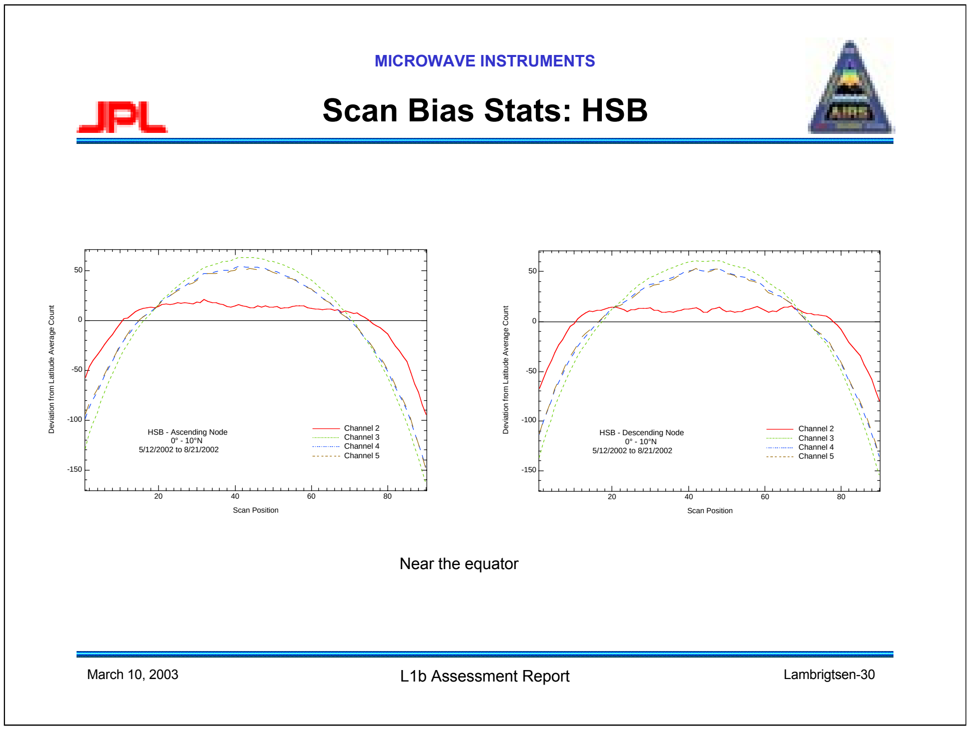
These plots show long-term averages of deviation of raw counts from long-term averages vs. scan position for all AMSU channels (near the equator). Note that surface sensitive channels exhibit apparent large anomalies - these are mostly caused by the large radiometric contrast between land and ocean and do not necessarily indicate scan biases. These plots should be used with caution and are reproduced here for illustration only.

The most interesting point to note are:

1. AMSU-A1 channels show a negative bias at the right edge of the scan compared with the left edge.
2. AMSU-A2 channels do not show a left-right asymmetry, but these are both surface sensitive channels, and further analysis is required.
3. Much of the scan dependence shown in these plots is due to zenith angle effects and do not reflect an instrument bias.

Note that the gain table given earlier can be used to translate scan biases estimated from these plots from counts to brightness temperature.



This is the same, for HSB. Here also a scan asymmetry is apparent.

It should be noted, however, that there is also a strong latitude dependence (which is also true for AMSU), including for the asymmetry.

MICROWAVE INSTRUMENTS

Moon in Field of View

Geometry

- May be visible in space-cal FOV
- Seasonal phenomenon
- Approximately half-moon when visible

Serendipity

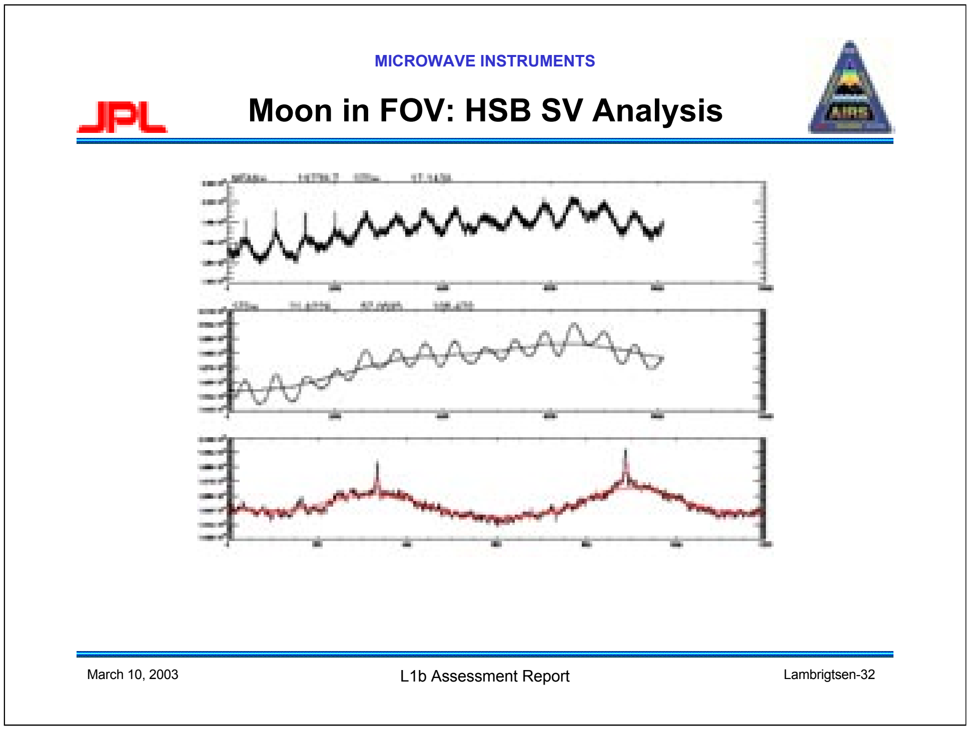
- Unexpected large “noise” spikes seen during optimal space view analysis
- After some head scratching: check moon angles
  - Yup, the moon was transiting near a particular SV position
- Foresight during ATBD creation ⇒ We monitor the moon’s position
  - Angle between moon and each space view is computed in L1a

Results

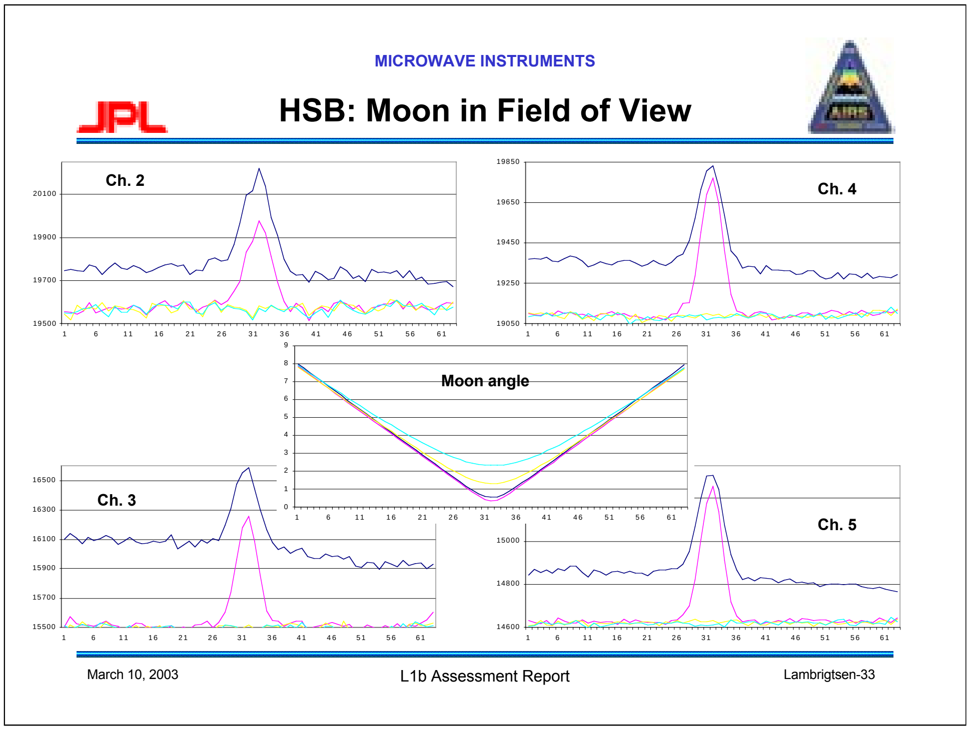
- Moon got to within 0.4° of center of HSB FOV
- Used data to generate moon profile
  - Peak signal ~ 20 K @ 183 GHz, ~ 15 K @ 150 GHz
- Will use to update moon-in-FOV flag criteria
  - May use to supplement pointing analysis

Occasionally, the moon enters the field of view during a space-view calibration measurement. This was foreseen, and the calibration algorithm accounts for this by rejecting space observations where the boresight is within a specified angular distance of the center of the moon. Once this happens, it typically persists for many scan cycles, as the moon slowly moves past the space view position, and it typically repeats for several orbits. It is seasonally cyclical. The effect on the calibration is negligible.

The next two pages shows an analysis of such a “lunar encounter” for HSB, where the effect is largest (due to its small FOV, which allows the moon to fill a significant portion of the FOV).



The lunar effect was first noticed during analysis of HSB data to determine the optimal space view position, when the instrument was in so-called “investigate Mode”. In this mode, it cycles through the four possible space view positions, so that each scan cycle has a new position selected. This increases the possibility of seeing the moon in one of the space observations. The effect appeared as large spikes in the cold calibration counts - illustrated above.



These plots show the effect of the moon in the four different space view positions. Each of the four corner panels shows the cold-calibration counts vs. time for a particular HSB channel and for each of the space view positions as the instrument cycled through them. The center panel shows the corresponding angle between the moon and the boresight vs. time.

Using the gain table given earlier, it can be seen that the effective brightness temperature perturbation reaches approximately 20 K - for a closest approach of about 0.5°.